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Technical Report 159

PEDO-ECOLOGICAL INVESTIGATIONS

BARROW, ALASKA

by

Jerry Brown
and
Philip L. Johnson

APRIL, 1965

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U.S. ARMY MATERIEL COMMAND
COLD REGIONS RESEARCH & ENGINEERING LABORATORY
HANOVER, NEW HAMPSHIRE

DA Task 1V014501B52A31
1V025001A13002

20040901176

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PREFACE

This report is an introduction to the cooperative research investigations underway at Barrow, Alaska (U. S. Army Cold Regions Research and Engineering Laboratory (USA CRREL) Projects 3.3B and 24.4), and includes field activities from the spring of 1962 to the summer of 1964. The principal purpose of this contribution is to describe the experimental design and the methodologies employed, and to briefly summarize the accomplishments to date. The authors are individually conducting other programs at Barrow which will be subjects of later reports.

This research was conducted by Dr. Jerry Brown, Soil Scientist, and Dr. Philip L. Johnson, Plant Ecologist, under the general supervision of Mr. James A. Bender, Chief of the Research Division, and Mr. Robert Frost, Chief of the Photographic Interpretation Research Division, respectively. The field work was generously supported by Arctic Research Laboratory under the direction of Max C. Brewer, and its material assistance is gratefully acknowledged. Many people have contributed to the technical work in both the field and laboratory. On behalf of Project 3.3B. the authors wish to express appreciation to Robert I. Lewellen who was responsible for much of the surveying, collection of field data, and ground temperature instrumentation; to Paul Sellmann for his part in the coring operation and other aspects of the field programs, and to Allen Tice for collection of ground temperature data. On behalf of Project 24.4 the authors wish to express appreciation to Theodore Vogel for assistance on the microclimatic studies and to John Dennis for vegetative sampling.

Appreciation is acknowledged to Dr. W. L. Culberson, Duke University, for identification of the lichen species and to Dr. W. A. Weber, Colorado University, and Dr. W. C. Steere, New York Botanical Garden, for determination of bryophyte species.

Manuscript received 3 August 1964.

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SUMMARY

This report is an introduction to the cooperative research investigations underway at Barrow, Alaska, and includes field activities from the spring of 1962 to the summer of 1964. The primary objectives of the study are to quantify the environmental parameters and ecosystem processes which are responsible for generating the complex Arctic landscape and to evaluate the effect of micro- and macrorelief upon soils and vegetation. The experimental design and methodologies employed for acquisition and analysis of data are described. Data are presented from 20 plots which include depth of summer thaw for 1962 and 1963, soil moisture content at 80 sample sites, soil chemical concentrations at the $\frac{3}{4}$-meter depth, selected soil temperature for an entire year, and lichen, moss, and vascular plant cover. Microclimatic data at 6 stations along a 2-km transect are presented for summer 1963. The interdisciplinary approach to these investigations has been directed towards an understanding of the edaphic, geomorphic, botanical, and ecological characteristics of the landscape, and to a lesser extent to their interactions with the microenvironment.

PEDO-ECOLOGICAL INVESTIGATIONS, BARROW, ALASKA

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Jerry Brown and Philip L. Johnson

INTRODUCTION

The understanding of the complex arctic tundra requires an approach that integrates the soil and biological sciences, specifically pedology and ecology. Pedology is that branch of soil science dealing with the natural laws governing the origin, formation, and distribution of soils. Ecology is that branch of biology dealing with the study of organisms in relation to their environment. The combination of these two disciplines can provide answers to fundamental problems that are encountered in the cold regions environment.

One basic principle of ecological theory holds that species are distributed in space and time as a function of their genetic potential to grow and reproduce in a specific environment. On the Arctic Coastal Plain, in spite of the subdued topography and high degree of physiognomic uniformity of the vegetation, species composition varies considerably from place to place. The degree and rate of species shift from one vegetation pattern or association to another is proportional to the steepness of the spatial environmental gradient. The complexity of the vegetation pattern has been recognized and described by many authors (e.g. Koranda, 1954; Britton, 1957; Churchill and Hanson, 1958; Bliss, 1961; Cantlon, 1961; Johnson and Billings, 1962; Johnson, 1963), and is a product, in part, of the macro-, meso-, and microtopography.

Arctic soils are similarly distributed across environmental gradients which are primarily controlled by slope and drainage. The soils change in order of increasing wetness or lack of drainage from well-drained arctic brown soils to upland tundra and meadow tundra soils to half-bog and bog soils (Tedrow and Cantlon, 1958). Associated with each soil is a corresponding plant community, although the soil-vegetation relationship becomes more difficult to characterize with increasing wetness in the soil.

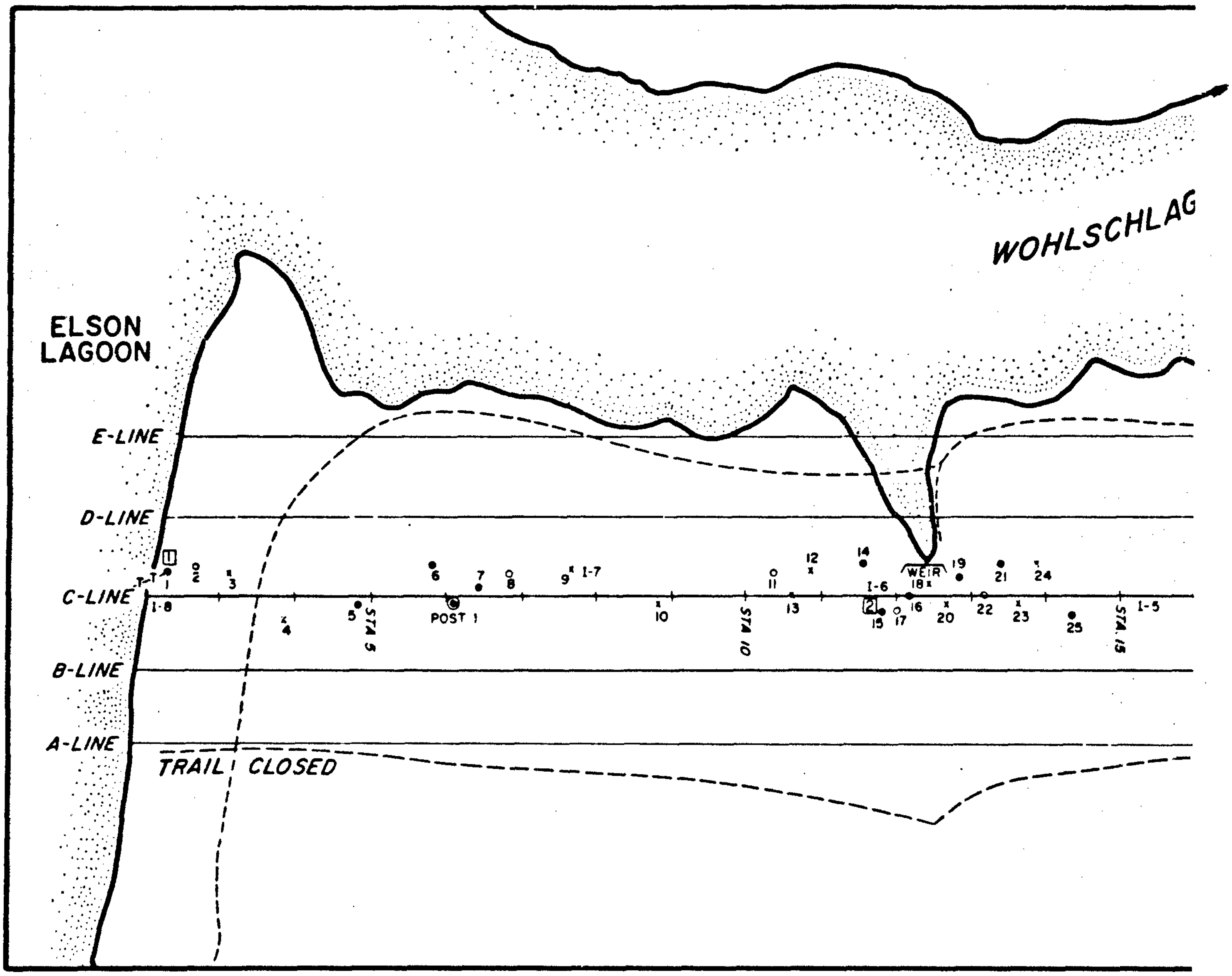
The correspondence of vegetation to soil type is a delicate indicator of environmental conditions. Cryopedologic phenomena that are manifested in the cold regions result in the instability of vegetation and soil. The classical concepts of succession, maturation, and climax (steady state) of both vegetation communities and soil type require careful interpretation for application in the Arctic. Topographic control of drainage, cryopedologic processes, and ice-wedge distribution are prime aspects of the physical environment influencing these complex soil and vegetation interactions. These interactions of soil, vegetation, and environment require further elucidation in this arctic ecosystem characteristic of the littoral coastal plain of northern Alaska. Towards this end an intensified pedo-ecological investigation was initiated by the authors in the summer of 1962 at Barrow, Alaska.

The primary objectives of the study are to quantify the environmental parameters and ecosystem processes which are responsible for generating the complex arctic landscape and to evaluate the effect of both micro- and macrorelief upon soils and vegetation. The development of methods for the acquisition and analysis of data is also considered. The interdisciplinary approach to these investigations has been directed towards an understanding of the edaphic, geomorphic, botanical, and ecological characteristics of the landscape, and to a lesser extent to their interactions with the microenvironment.

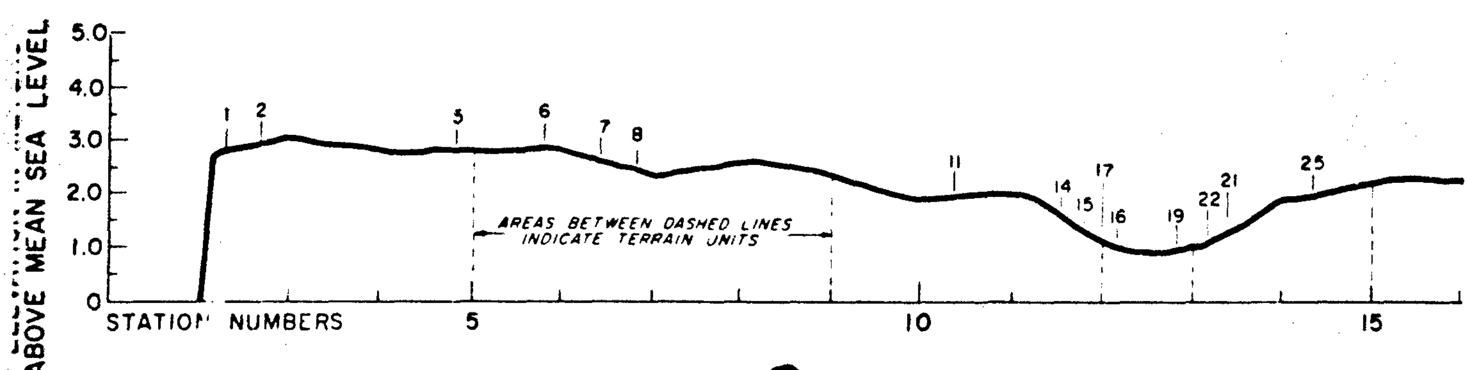
The study area is located at the northern extremity of the Arctic Coastal Plain of Alaska (Fig. 1). Geomorphically the region is flat, dominated by ice-wedge polygons, covered with shallow oriented lakes and drained lake basins, and underlain by perennially frozen ground to depths in excess of 300 meters. The near-surface sediments consist

Figure 1. Photo mosaic of Barrow, Alaska. Dashed line indicates location of study area. (Compiled from controlled mosaics prepared by U.S.N. Photographic Interpretation Center, February 1957.)

CRF



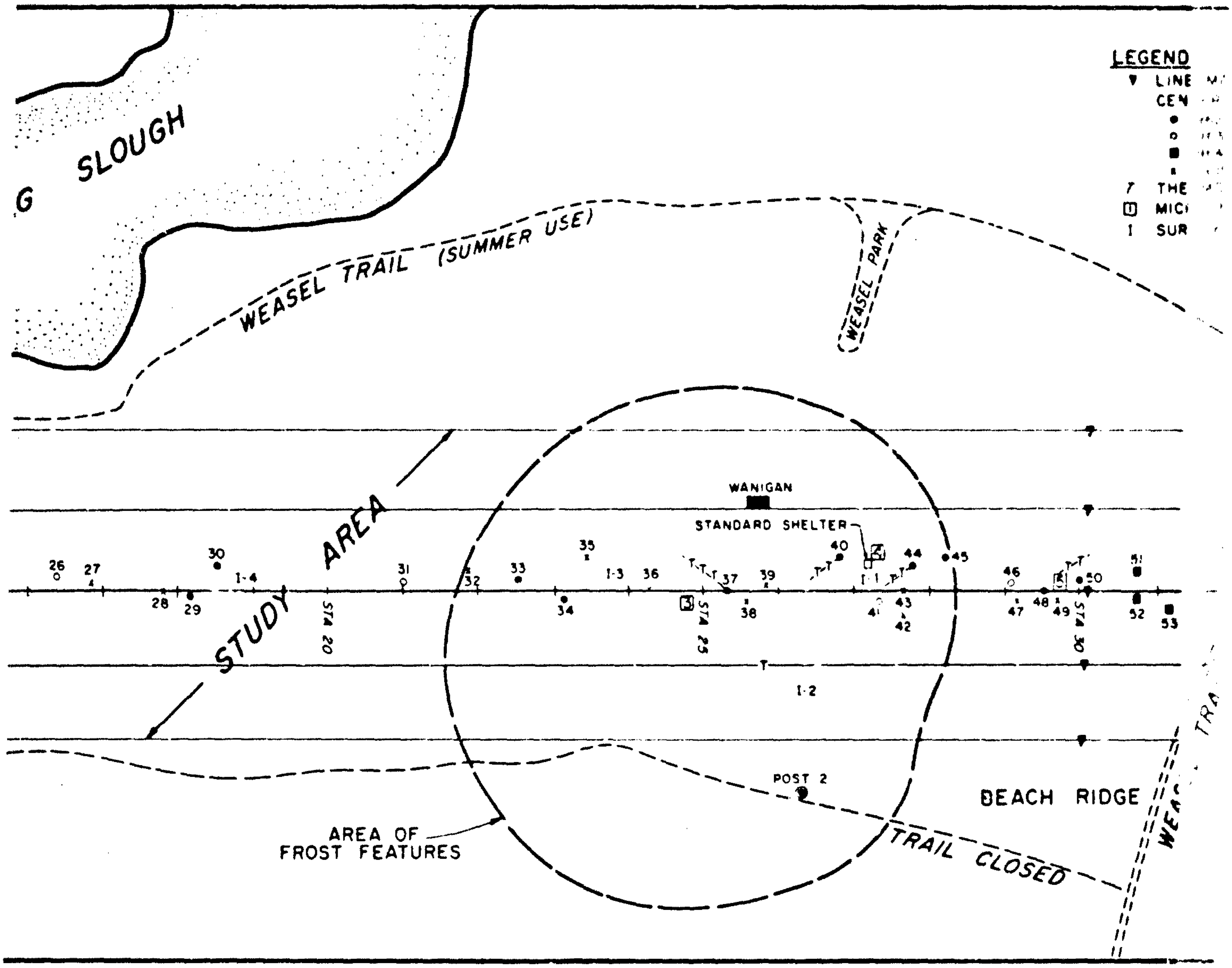
WOHLSCHLAG
ELSON LAGOON
E-LINE
D-LINE
C-LINE
B-LINE
A-LINE
TRAIL CLOSED
WEIR
POST 1
STA 5
STA 10
STA 15
I-5
I-6
I-7
I-8



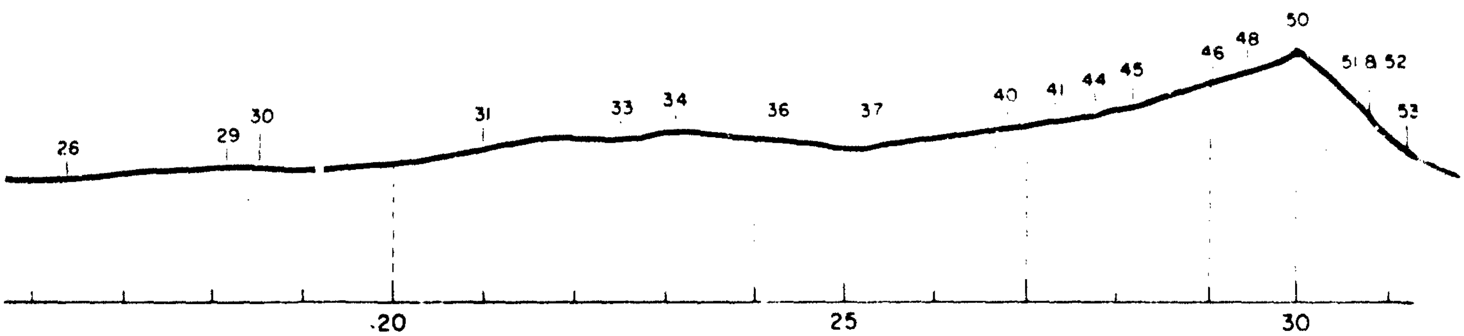
ABOVE MEAN SEA LEVEL
5.0
4.0
3.0
2.0
1.0
0
STATION NUMBERS
5
10
15
AREAS BETWEEN DASHED LINES INDICATE TERRAIN UNITS

A

REL STUDY AREA, BARROW, ALASKA



LOCATION PLAN OF PLOT DESIGN



PROFILE ALONG C-LINE

B

.ASKA

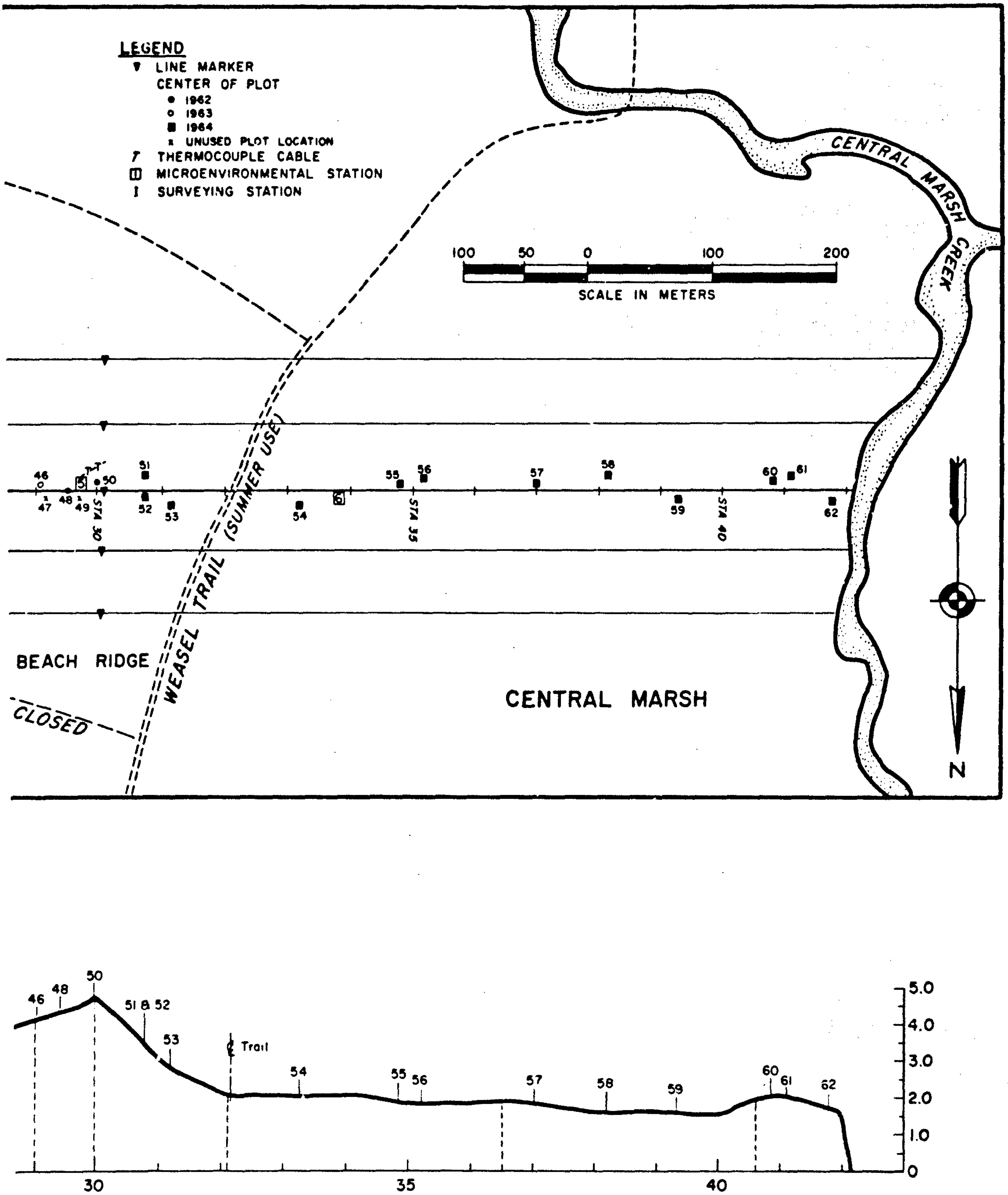


FIGURE 2

C

of a Pleistocene marine and non-marine deposit (Gubik formation). The soils are predominantly fine-grained, wet tundra soils with an average seasonal thaw of approximately 0.4 m in thickness. The vegetation is typical arctic tundra, with an abundance of sedges, grasses, herbs and a few dwarf shrub species. The mean annual air temperature at Barrow is -12C with less than 250 mm precipitation recorded annually. A bibliography of the regional literature has been prepared (Brown, 1964).

PROGRAMS OF STUDY AND OBJECTIVES

The following outlines the major studies undertaken in this joint investigation and their objectives.

1. Pedologic studies: To determine pedologic processes across geologic and environmental gradients in a wet arctic region.

Soil sampling: To characterize the chemical, physical, and mineralogical properties of the soil and substrate and relate these findings to present and past cryopedologic processes.

Seasonal thaw: To determine rate and maximum depth of seasonal thaw, and correlate seasonal thaw with climatic data and soil frost structures in order to evaluate present and past fluctuations in depth of thaw.

Ground temperatures: To determine temperature gradients in the ground due to differences in surface elevations and vegetation and correlate physical and chemical properties in the soil as a result of these gradients.

2. Vegetation Studies: To determine the ecological processes, species aggregations, and important interactions with edaphic and environmental parameters.

3. Microenvironmental studies: To determine the variations in climate and surface topography which in turn influence the spatial distribution of vegetation types and soil properties.

Microclimatic studies: To determine variation in radiation, air temperature, wind, and rainfall along the plot transect and to evaluate possible effects on soil and vegetation.

Frost features: To determine distribution of non-sorted circles and nets, their characteristics, origin, and stability.

Microrelief studies: To determine the effect of microrelief upon soil characteristics including depth of thaw, chemical properties, and moisture, and upon the distribution of vegetation.

DESIGN OF STUDY AREA

An initial base line approximately 2100 meters long (C-line) was established between Eison Lagoon on the east and the drainage of Central Marsh Creek on the west (Fig. 2, 3). Two additional base lines were located on each side and parallel to the C-line at 50-m intervals. This study area, a 200 m wide traverse approximately 2.1 kilometers in length, represents terrain characteristic of the Barrow area, and is relatively free of vehicular trails. Elevations at 50-m horizontal intervals along the C-line were determined. Based upon this elevation profile and geomorphic features, the traverse area between the lagoon and the raised beach ridge was divided into 10 terrain units, centered along the C-line. A total of 50 points, 5 points per unit, were distributed within a 50 m wide strip centered on the C-line by use of a coordinate system and a table of random numbers. During summer 1962, two of the five points in each unit were selected as the center points of 10 x 10-m plots. Figures 4 to 11 are aerial oblique photographs of the study area indicating the location of the plots along the C-line (Fig. 3). In the summer of 1963, a third point in each unit was utilized as a plot location, thereby leaving two unused points in each of the 10 units for future site selection and study. In 1964, four additional terrain units were located in the Central Marsh area with a total of 20 potential plots. Three plots were established in each new unit, making a total of 42 plots presently under investigation. The distribution of the center points of the plots and location of existing instrumentation are presented in Figure 2.

Figure 3. Air photo of study area with location of C-line.
(U. S. Air Force photography)

Figure 4. Aerial oblique of Plot 1 along shoreline of Elson Lagoon.

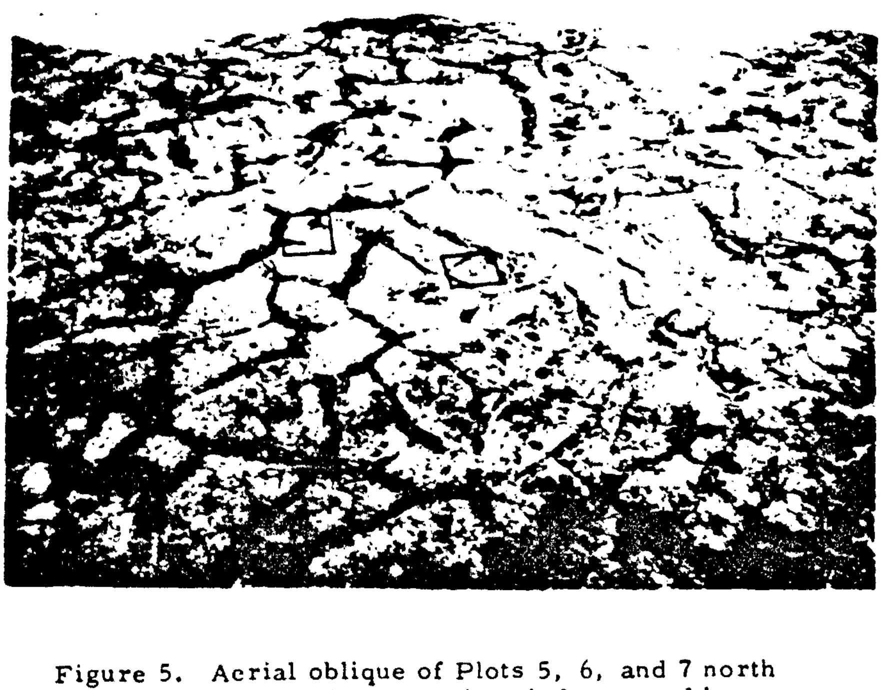


Figure 5. Aerial oblique of Plots 5, 6, and 7 north of Wohlschlag Slough. Note the wind-scoured bare surfaces concentrated on a few scattered high-center polygons.

Figure 6. Aerial oblique of Plots 14, 15, and 16 on east slope of drainage into Wohlschlag Slough and Plots 19 and 21 on the west slope.

Figure 7. Aerial oblique of Plots 29 and 30 which characterize the minimal relief along the transect.

Figure 8. Aerial oblique of Plots 33 and 34 in an area of high-center polygons and Plots 37 and 40 (extreme right side) in an area of frost features. The many bare frost scars are the most conspicuous type of frost feature.

Figure 9. Aerial oblique of Plots 44, 45, 48, and 50. The beach ridge represents maximum macro- and microrelief in the area.

Figure 10. Aerial oblique of Central Marsh. The borders of several small ponds are filling with Arctophila fulva.

Figure 11. Aerial oblique of western extreme of study area bordered by Central Marsh Creek.

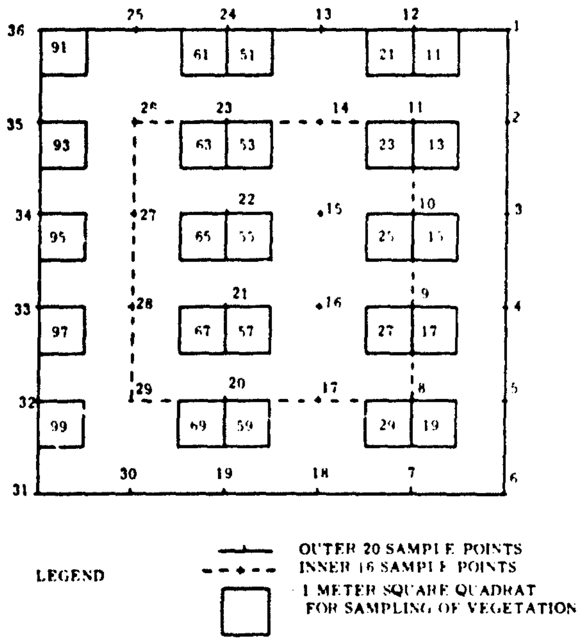


Figure 12. Subdivision of 10 x 10-m plot for sampling of soil and vegetation.

The 10 x 10-m plots are centered on the randomly selected points and oriented parallel to the C-line. The plot is subdivided into a grid of 2-m squares by permanent markers and strings. This results in a total of 36 permanent intersections, with coordinates numbered consecutively (Fig. 12). A secondary interior plot containing 16 sample points is used for specific sampling techniques to avoid edge effects of the peripheral points.

PEDOLOGIC STUDIES

The objective of these investigations is to determine the pedologic processes that are occurring and have occurred in this cold region of northern Alaska. These cryopedologic processes consist of physical, chemical, and thermal mechanisms that result in such phenomena as frost heaving, frost churning, and contraction of the soil and substrate. Programs of soil sampling and measurement of depth of thaw and ground temperature are considered paramount in understanding and quantifying these complex processes and the soil-vegetation interactions.

Sampling

Two sampling programs have been established on the plots: a selected sampling on paired plots to ascertain seasonal changes in soil properties and a comprehensive sampling of the initial 20 plots.

The seasonal sampling was designed to determine the difference caused by freeze-back phenomena and annual changes in moisture regimes. Prior to the 1962 freeze-back, a vertically thawed soil section was sampled at a specific point in each of 10 plots. Moisture and soil chemical properties were determined. A similar nearby site was sampled in the spring of 1963 and 1964 while the soil was still frozen. All sampling was conducted with great care to avoid heterogeneity of the sample sites and contamination. The frozen samples for chemical analysis were obtained from a 15 cm diam core. A core 6.5 cm in diameter was obtained adjacent to each of these for moisture determination.

Chemical analyses throughout these studies consisted of determining the electrical conductivity or conductance of a soil-water extract.

The comprehensive sampling program of all 20 plots was accomplished in spring 1963. The purposes of this sampling were to characterize the soil properties along the plot transect, to examine the chemical properties and frost structures of the seasonally and perennially frozen soil, to areally deduce relative frost characteristics of these soils, and to visually determine fluctuations in depths of thaw.

The sample sites were restricted to the inner 16 points in each of the 20 plots. From this grid, eight points representing four minimum and four maximum values of the 1962 thawed soil zone were selected. For the 1963 sampling, two of the points representing minimum and two representing maximum values of the preceding year's thawed soil were chosen randomly and sampled in the frozen condition. The frozen sample consisted of a core 6.5 cm in diameter and approximately 1 m in length. A total of 80 cores were obtained, of which 22 terminated in ice wedges. The cores were photographed, cut into 5-cm increments and analyzed. Moisture determination was conducted on all 5-cm segments of all 80 cores. Chemical analyses were usually confined to two samples per core; a 5-cm increment from approximately the center of the 1962 thawed zone and a second segment 50 cm below this sample in perennially frozen ground. Both samples were thawed and the soil water extracted for determination of conductance. Samples of ice-wedge ice were thawed, and the amount of residue and the conductance of the water determined. Figure 13 illustrates a typical core, the analytical sampling procedure employed, and the percent moisture (oven-dried basis) for each segment.

The frozen samples were obtained by using a Concore drill mounted on a weasel-drawn, 1-ton sled (Fig. 14). The drill was equipped with a single-walled core barrel and utilized a tungsten carbide bit. Air-cooled compressed air was employed to remove the frozen cuttings and to prevent chemical contamination commonly encountered with conventional drilling methods.

<u>Results of soil sampling</u>

Partial chemical and moisture data from the 1963 spring sampling are presented in Figure 15. The selected moisture values are obtained from the mid-sample of the 1962 thawed zone. Therefore, these moisture contents represent the values after freeze-back and reflect possible moisture migration. The bar graphs of moisture content and relative elevation differences are presented in order of increasing thickness of the thawed zone for each plot.

Several questions can be partially resolved from this preliminary data:

(1) How does microelevation influence the depth of thaw and the moisture regime of the soil?

(2) Are the soils with a minimum thaw the wettest?

(3) Do the chemical properties of the soils along the transect differ significantly?

A preliminary examination of the data for the 80 cores indicates that microelevation within the plot does not control the extremes in depth of thaw or soil moisture. The maximum elevation in a plot is not necessarily underlain by the maximum thaw or vice versa. In fact, this association is divided approximately equally among both possibilities. The extremes in microelevation do not control the extremes in moisture distribution. Sample points of maximum elevation are not necessarily the driest at their mid-sample. A better correlation exists between the depth of thaw and the moisture content of the mid-sample. That is, in 14 of the 20 plots, the two minimum thawed zones were wetter than the two maximum thawed zones in their respective mid-sample. These conclusions can be observed in the bar graphs of Figure 15.

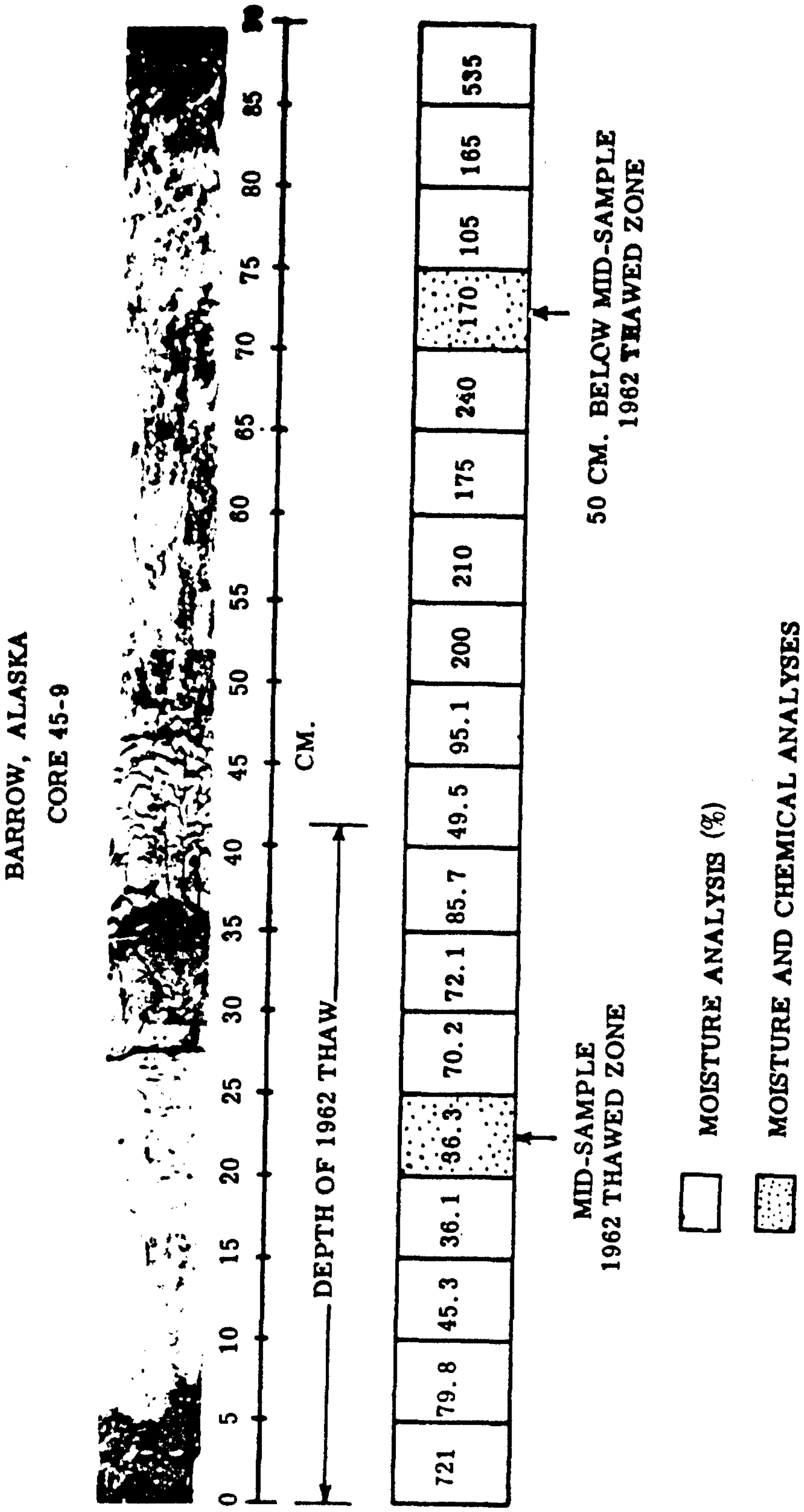


Figure 13. Core morphology and analysis scheme.

Figure 14. Portable drill mounted on a 1-ton sled.

However, the soils with minimum thaw were not necessarily the wettest when the entire thawed zone is considered. The fact that buried peaty inclusions are present in the soil complicates interpretation of the data. The inclusions lead to abnormally high moisture contents (oven-dried basis) such as are observed in Plot 25. Consequently, until analysis of the data is complete, with the necessary corrections for the buried organic matter, caution is advisable in further interpreting the data.

The chemical data are presented for the soil-water extract obtained after thawing the perennially frozen portion ($\frac{3}{4}$ m) of each core. The area in which the maximum number of frost features or non-sorted circles occur is extremely low in relative salt concentration, as observed between Plots 30 and 40. This may be significant in explaining the presence of the circular frost features in this area. Comparison of seasonally thawed soils and the underlying frozen zones indicates approximately 10 to 20-fold increase in the salt content downward between the two groups of samples. However, there is considerable scatter from plot to plot and from core to core, so that further conclusions again await more detailed reduction of the data and supplemental selective sampling in 1964.

Seasonal thaw of soil

This series of measurements provides information on the rate of seasonal thaw, on the seasonal differences in the maximum amount of thaw, on the relationship of micro-relief, elevation, vegetation and soil properties to thaw, and provides the record necessary for correlating the climatic data and core morphology with present and past fluctuations in the depth of thaw.

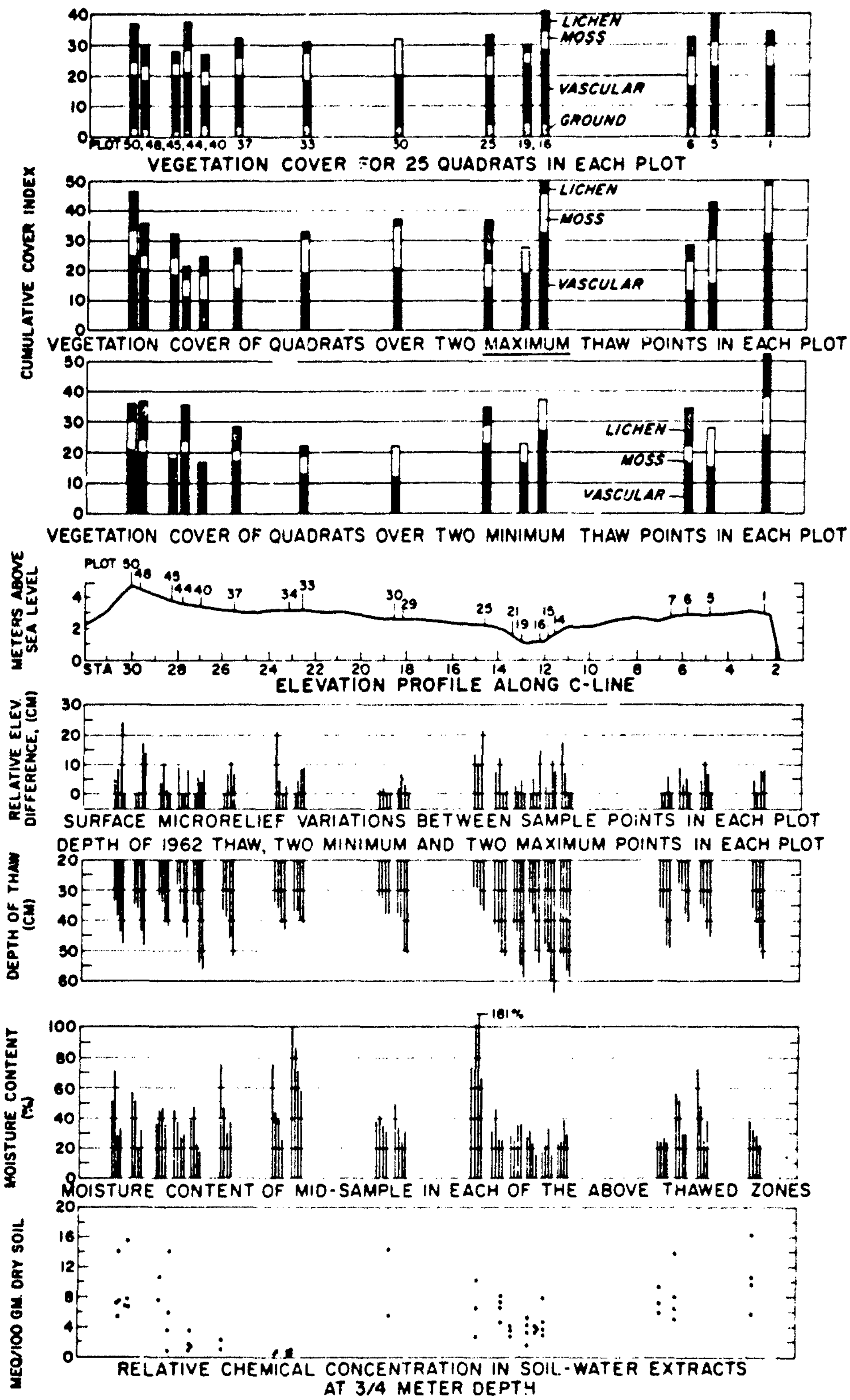


Figure 15. Soil and vegetation data along plot transect.

The plots are probed periodically throughout the summer to ascertain the thickness of the thawed-soil zone. The probe is a pointed steel rod 1 cm in diameter. Average readings to within 1 cm accuracy are recorded at approximately 1-week intervals starting in late June and terminating when the thawed zone is at a maximum thickness in late August or early September. To avoid unnecessary disturbance of the plots during the summer, only the marginal 20 grid points are measured. All 36 points are probed for the final seasonal measurements.

Figure 16 contains the average maximum thickness of thawed soil in each plot during 1962 and 1963, and cumulative degree days above 0C (thawing index) for 1962, 1963, and the 30-year mean. The 1962 probing of 720 points averaged 2.5 cm thicker than the 1963 measurement. Meteorological data support these differences in ground measurement. These data can serve to more precisely correlate past climatic observations with depth of thaw. Additional data from these climatic-sensitive measurements are available over the past 10 years, including the work of Drew et al. (1958).

Ground temperature

The determination of thermal gradients in these arctic soils is required to evaluate the rate of chemical and moisture movements, the rate and amount of ground contraction and expansion, and the effect upon vegetation, particularly the root system. In addition, the temperature record is used to correlate depth of thaw and freeze-back under different microrelief conditions and to correlate frost structures with rate of freeze-back.

Stacks of prefabricated thermocouples were installed selectively in the study area to provide information on the temperature gradient in the soil due to environmental gradients. The thermocouple stacks consist of 11 or 12 individual thermocouples spaced at small increments with depth. The 12-point installation consists of thermocouples at depths of 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 75, 100 cm. The 11-point installation consists of thermocouples at 7.5, 15, 22.5, 30, 37.5, 45, 52.5, 60, 75, 105, 165 cm. Additional thermocouples are placed at the soil-air interface for ambient control.

The cables were installed in late spring 1963. A frozen soil core was obtained from the proposed site within the plot. The individual thermocouple was adfrozen into a small hole drilled in the core (Fig. 17). The core with its attached thermocouples was lowered into the original hole and a slurry of water and soil was poured into the hole and allowed to freeze back. This method reduces physical disturbance of the soil. These field units are easily read by using either a rotary switch and a portable potentiometer or an extension cable to a standard recorder in a heated building. During freeze-back in 1963, a combination of intermittent and continuous recordings of seven thermocouple stacks (Plots 44, 40 and 37) was possible using two 20-point Speedomax G recorders. Daily measurements with a portable meter are also obtainable. Locations of these and other units are presented in Figure 2.

Three microrelief types were instrumented with the 12-point thermocouple assembly. In Plot 44, the hummocky microrelief is the site of two thermocouple installations with a difference in elevation of 12 cm between them. Thermocouple stacks were placed in an ice-wedge trough and adjacent raised polygon edge in Plot 40, with a difference in elevation of 18 cm between the two assemblies. The three thermocouple sites in Plot 37 are a bare mineral frost scar and two adjacent vegetated sites. Their relative locations are illustrated in Figure 18 along with a year's record of selected soil temperatures taken at approximately monthly intervals.

The vertical and lateral thermal gradients and the cooling and warming rates are observed in Figure 18. The bare mineral surface undergoes considerably more thermal stress throughout the year, whereas the vegetation and thick snow cover dampen the thermal fluctuations in the lower areas. Daily readings indicated that the seasonal thawed zone remained at zero ("zero curtain," Brewer, 1958) throughout September in all but the surface soils and was completely dissipated, first in the bare exposed soil site (37-1), then in 37-2, and in 37-3 by late October. In 1964, a 20 m long thermocouple assembly was installed near Plot 37. The hole was back-filled entirely with a slurry.

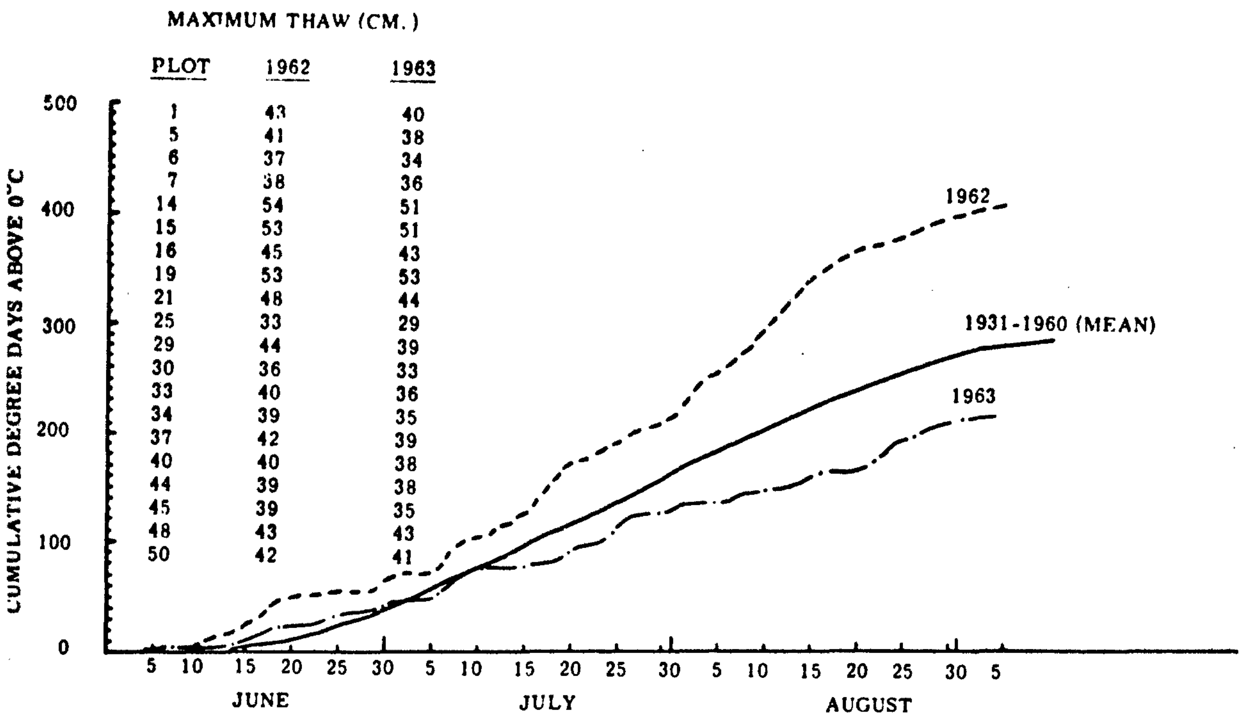


Figure 16. Differences in maximum depth of thaw and thawing indexes (1962 and 1963).

Figure 17. Placement of thermocouples in frozen soil core prior to refreezing in drill hole.

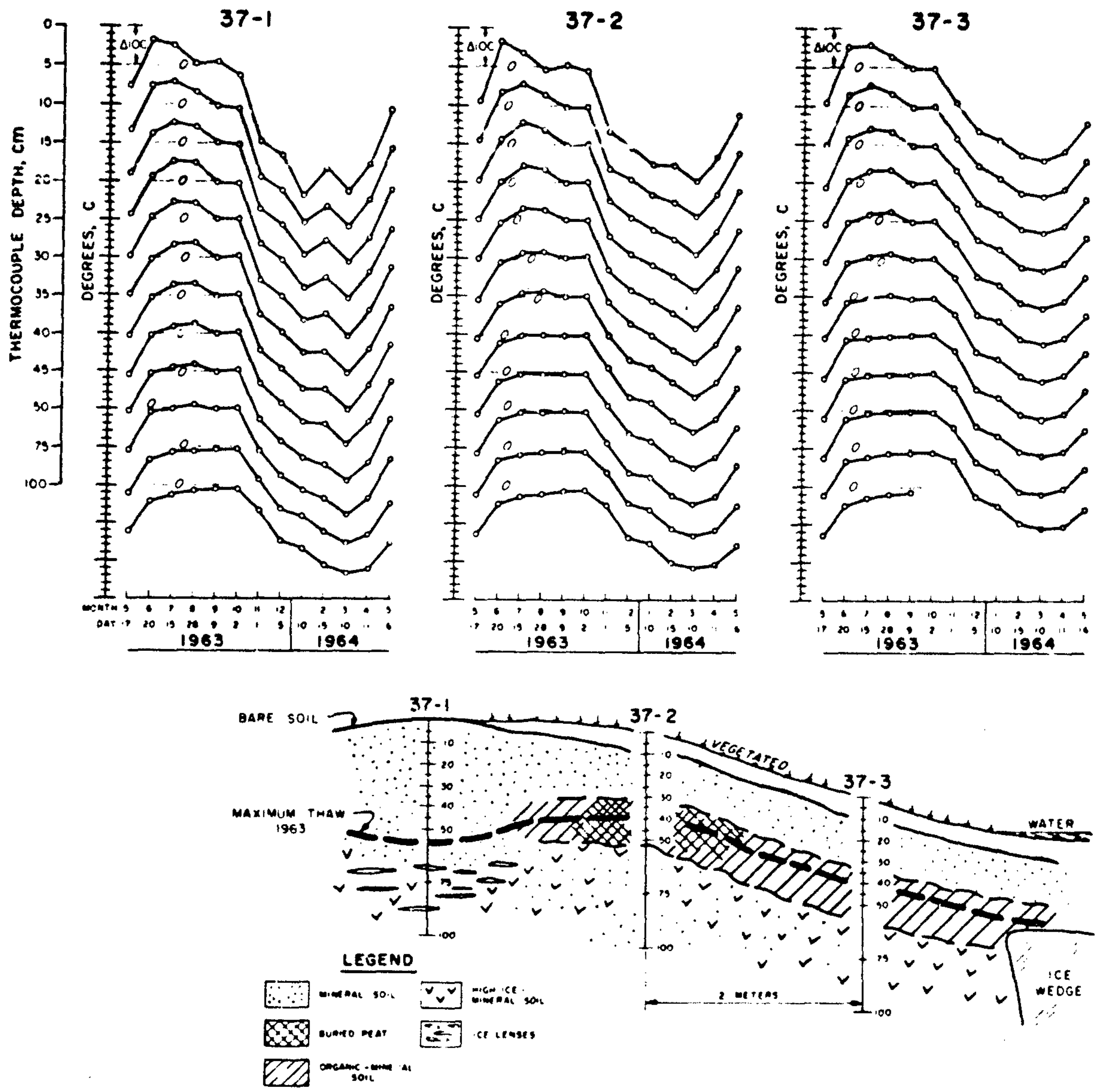


Figure 18. Thermocouple installation and selected soil temperatures, Plot 37, Barrow, Alaska. The vertical temperature scale is read above or below the zero isotherm for each individual thermograph. Each minor scale division represents 2C.

VEGETATION STUDIES

The distribution of plant species across environmental gradients constitutes an inte-ıted expression of the many external factors and interactions. A basic understanding these species groupings in relation to the microhabitats and associated edaphic ıditions was central to the sampling approach.

npling

Vascular flora in the Barrow vicinity is quite limited. Hultén (1961) lists 106 :cies which he observed or collected while Wiggins (1962) enumerates 435 species for Alaskan Arctic Slope. Most of the vegetation at Barrow is composed of less than vascular species, the greatest variety of which occur on the beach ridges and raised ygons that offer a maximum number of niches. Mosses and lichens are very ındant both in number and species.

In the 10 x 10-m plot, a grid of 25 regularly spaced 1 m square quadrats was .ized (Fig. 12). A seven-point cover scale based on percentage of ground covered 1%, 1-5%, 5-10%, 10-20%, 20-50%, 50-75% and 75-100%) was employed to tabulate :ry recognizable species in each quadrat. A computer analysis of the vegetation data ng the summation of Chi Square to divide the population into groups of species with ıimal heterogeneity (Williams and Lambert, 1959) will permit mapping areas of tistically similar vegetation which can then be correlated with environmental para-ters. The distribution of quadrats within a plot grid permits analysis of the data ıer by 1 m square units or 1 x 2-m units, thus permitting an evaluation of the in-ınce of quadrat size on the analysis. In this way an assessment of: (1) species group-s within 10 x 10-m plots, (2) groupings between 10 x 10-m plots, and (3) comparison h environmental data can be made in which the vegetation classification is an ependent variable. This is thought to be a distinct advantage over correlating various sical measurements with the plants which happened to be growing at the point of asurement.

;ults of vegetation sampling

The vascular, bryophyte, and lichen species collected along the study transect are ed in Appendix A. Several questionable identifications, particularly of mosses and :rworts, await attention of appropriate taxonomic authorities.

A summary of the vegetation data is presented in Table I. The total number of cies for each plot remains remarkably constant, but the shift in species composition relative cover is obvious in the field and in Figure 15. More than half of the etative cover in a plot is made up of vascular plants. This is not necessarily true ndividual meter-square quadrats. Areas of greatest productivity in terms of nass correspond to those plots with the highest cover of vascular species. The test plots have the highest bryophyte cover; the driest plots the highest lichen cover. ıce, the expected inverse relationship between moss and lichen cover values (Fig. is obtained. This relationship is more conspicuous on individual quadrats which .ect the role of microrelief. High litter values correspond to plots with high pro-tivity, high lemming activity, and therefore high values for the combined ground-:r category.

The accumulation of organic matter is not only biologically important, but a ıificant pedological and geomorphic process in the Arctic. Measurements of photo-thesis and respiration of tundra plants *in situ* by species and by habitat are direct :xes of carbon production. The rate of carbon accumulation is important for perly interpreting soil-plant relationships. First approximations of these rates e attempted in summer 1964 with the use of a portable infrared CO_2 analyzer.

The species listed in Table I represent mean cover values greater than 1% (cover le values 2-7) for the grid of 25 quadrats. These cover values were totaled and the cies are listed in decreasing order of cumulative cover index for the 14 plots sampled. cumulative cover index for vascular, bryophyte, and lichen species is plotted in ure 15 and expressed as a percentage of total plant cover in Table I.

Table I. Species and cover distribution along the plot transect.

Plot number	1	5	6	16	19	25	30	33	37	40	44	45	48	50	Total
Number species	44	45	44	48	43	47	22	41	52	38	53	47	46	58	44
	Percent cover														
Vascular species	55	47	40	62	63	45	52	49	52	45	50	65	46	49	51
Bryophyte species	24	24	21	25	16	26	34	28	18	20	19	13	14	12	20
Lichen species	13	22	27	3	5	27	1	12	17	20	24	14	34	32	17
Ground and litter	8	7	12	10	16	12	13	12	13	15	7	8	6	7	10
Species	Mean cover scale														Cover index
Carex aquatilis	2.7	3.5	1.3	2.4	2.2	3.1	3.4	2.5	3.1	1.8	3.2	3.6	1.0	1.2	35.0
Dupontia fisheri	4.8	2.1	2.6	4.1	3.8	1.8	4.5	3.6	2.3	1.4		3.4			34.4
Eriophorum scheuchzeri	1.8	1.8	1.7			1.4	2.6	3.9	2.3	4.2	2.0	1.8			23.5
Eriophorum angustifolium	1.5	2.6	1.7	3.5	2.5	2.6					1.7	1.8	1.6	1.0	20.5
Poa arctica	3.7	2.9				1.6	3.4				2.3	2.7	1.8	1.8	16.8
Petasites frigidus		2.9		1.8							2.3		2.0	2.2	11.2
Saxifraga cernua			1.3	1.7	1.4	1.3	1.7	1.4				1.1			9.9
Arctagrostis latifolia		1.2									1.5		2.2	2.2	7.1
Luzula nivalis						1.7			1.4		1.3			1.2	5.6
Luzula confusa		1.0							1.0				1.6	1.8	5.4
Saxifraga foliosa						1.2		1.0	1.0	1.3					4.5
Stellaria laeta				1.0	1.0				1.2					1.3	4.5
Calamagrostis neglecta			2.2	2.0											4.2
Salix pulchra													2.0		2.0
Salix phlebophylla														1.9	1.9

It is at once apparent that Carex aquatilis (sedge), Dupontia fisheri (grass), and two Eriophorum species (cotton grass) constitute the majority of the plant biomass in each plot and in the study area as a whole from the lagoon to the beach ridge. Some species occur primarily on the beach ridge such as Salix pulchra (dwarf willow) and S. phlebophylla (dwarf willow). The beach ridge is also the area of low cover values for the ubiquitous grass and sedge species and high floristic diversity, particularly for lichens.

The relationship of vegetation change between plots along the transect is illustrated in Figure 15. Lichen species in particular are a sensitive indicator of better-drained sites. Plot 45, for example, more nearly resembles Plots 33 and 37 than the beach ridge plots adjacent to it. The deeper thawed zone associated with drainage slopes is reflected in the vegetation of Plots 14 through 21. The portion of the transect characterized by minimum microrelief (Fig. 7) is also a zone of low species diversity and vegetation uniformity.

Correlation of the vegetation with soil parameters is not obvious when the data are grouped according to 25 quadrats per plot. Microrelief apparently confers too much heterogeneity upon the large sample size. Areas the size of individual meter square quadrats or smaller must be examined for homogeneity, and therefore maximum correlation with site differences. For example, a better relationship is found by plotting cover values of plant taxa in quadrats over points of maximum and minimum 1962 thaw depths in each plot (Fig. 15). These points do not necessarily correspond to maximum and minimum microrelief or moisture levels. Statistical correlation between species and physical parameters is the subject of a later report.

MICROENVIRONMENTAL STUDIES

The purpose of these investigations is to delineate and quantify the parameters responsible for high order variability in the soils and vegetation and to attempt to answer questions such as: Does microclimate differ sufficiently to be the major cause of the soil and vegetation variability? What quantitative effect does microrelief have upon the soil and vegetation? Under what environmental, physical, chemical, and thermal conditions are the circular frost features generated?

Microclimatic studies

Considerable climatic data have been and are being collected at Barrow, Alaska, by other workers (Mather and Thornthwaite, 1956, 1958; Clebsch, 1957). To supplement this information and to compare units of the transect climatically, six microclimatic stations were established in 1963 at (1) Elson Lagoon, (2) weir site, (3) wanigan, (4) frost feature area, (5) beach ridge, and (6) Central Marsh (Fig. 2). Data for the period 12-25 July 1963 are presented for comparison between stations and with U. S. Weather Bureau data from Barrow Village, which is located approximately 7 km west of the study area and within ½ km of the Arctic Ocean.

Radiation. Shortwave, incoming radiation was recorded at the Elson Lagoon station (1) and the beach ridge station (5). A Belfort pyrheliograph was used at Station 5 and an Italian actinograph was used at Station 1. Both instruments are very similar in mechanical operation. The planimetered daily radiation values are comparable with U. S. Weather Bureau values compiled from 20-min readings with an Eppley, 50-junction pyrheliometer (Table II). Agmet and Beckman-Whitley all-wave net radiometers were operated intermittently near the wanigan and recorded on a 2-pen Leeds and Northrup Speedomax AZAR recorder. No data are presented for these instruments at this time.

Air temperature. Maximum-minimum thermometers at ground level were shaded from direct solar radiation by shields constructed from two arcs of tin superimposed with a 15-mm airspace between them. The tin shields were fabricated by splitting number 5 juice cans and removing both ends.

Values for a selected period are presented in Table III. Newly designed aluminum instrument shelters (Vogel and Johnson, 1964) shielded a recording Bourdon tube-type thermograph at each station for continuous weekly ambient temperature records. A standard weather shelter was maintained at Station 4 with a maximum-minimum thermometer and a thermograph for comparison with U. S. Weather Bureau records.

Table II. Solar radiation values, 1963 (langleys per day).

Date (July)	Station 1	Station 5	Barrow (U.S.W.B.)
12	399.6	365.4	347.1
13	677.1	558.9	507.3
14	799.2	668.8	715.7
15	632.7	510.0	665.0
16	155.4	160.0	124.4
17	288.6	326.4	342.5
18	288.6	326.4	-
19	643.8	657.2	689.8
20	388.5	492.2	455.3
21	521.1	569.7	525.7
22	321.9	303.0	323.5
23	277.5	406.0	250.0
24	377.4	575.1	462.1
25	510.7	203.0	480.2
Total (*)	5993.4	5794.1	5878.8

(*)Total values for period, omitting 18 July.

Wind. Bendix-Friez three-cup anemometers with the cups 65 cm above ground level and an additional unit on the wanigan roof at 7 m were recorded on an Esterline-Angus event recorder. The values in Table IV are summarized as mean hourly values per 24-hour day from a continuous strip chart.

Precipitation. Precipitation was measured at Stations 1, 2, 4, 5, and 6 by collecting in number 5 juice cans having a collecting area of 88.2 cm^2, five cans at each station. Paraffin was used to seal the container and prevent moisture from adhering to the joint at the bottom of the can. Precipitation was measured in a graduated cylinder following each major storm period. The data are presented in Table V.

Results of microclimatic measurements

The present microclimatic data compare favorably with the U. S. Weather Bureau at Barrow over relatively long periods. However, they differ substantially on a day-to-day or storm-period basis, thus agreeing with the conclusions of Mather and Thornthwaite (1956, 1958) that differences were due to random variation. This was observed for both the radiation and precipitation measurements. There were large deviations on a daily or storm basis, yet they agreed remarkably well over longer periods (see Tables II and V).

The temperature and wind data demonstrate the effects of cold air drainage and topographic shielding. Minimum temperatures in the depression at Station 2 are consistently among the lowest readings. The highest readings for any one day are generally at the lagoon edge or in Central Marsh, but seldom at Station 2. Stations 1, 2, and 6 demonstrate the greatest extremes in wind velocity. When the velocity is highest along the lagoon edge it is generally lowest at the Central Marsh station. On several occasions the high velocities in Central Marsh were paralleled by low velocities at Station 2.

Table III. Maximum-minimum air temperatures (°C) at ground level, 1963.

Date (July)	1		2		3		4		5		6		Shelter		U.S.W.B.	
12	5.6	1.1	4.5	0.0	4.5	1.1	5.0	0.6	4.5	0.6	4.5	1.1	-	-	2.2	-1.1
13	13.3	-1.1	6.2	-2.2	9.4	-1.1	5.6	-1.7	6.2	-1.1	3.9	-1.7	2.8	-2.2	0.6	-1.7
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.2	-2.2
15	15.0	-1.1	7.8	-2.8	11.1	-1.1	10.0	-1.7	8.9	-1.7	6.2	-1.7	1.7	-1.7	2.8	-1.1
16	10.5	-0.6	6.2	-1.7	8.9	-1.1	8.3	-1.1	6.7	-1.1	8.9	-1.1	5.6	-2.2	1.7	-1.1
17	7.3	0.6	5.0	0.0	6.7	0.6	5.6	0.6	6.2	0.6	9.9	0.6	2.2	0.6	2.2	0.6
18	7.8	1.7	6.2	0.6	10.0	1.1	6.7	1.1	7.8	1.1	6.7	1.1	3.4	0.6	1.7	0.6
19	11.1	0.6	9.4	0.0	11.1	0.0	12.2	0.0	11.7	0.6	11.1	0.0	6.2	0.0	9.4	0.0
20	13.3	3.4	12.2	1.1	16.7	2.2	13.3	1.1	16.7	1.7	14.5	1.7	8.9	1.1	10.0	1.1
21	13.3	3.4	10.0	1.1	13.3	1.7	12.8	1.1	12.2	1.1	13.3	1.1	7.8	1.1	5.0	0.6
22	7.3	1.1	6.7	0.0	7.8	0.0	7.8	0.0	7.8	0.0	6.7	0.0	5.6	0.0	1.7	0.6
23	7.8	1.7	6.2	0.6	6.7	1.1	6.7	0.0	6.7	1.1	5.6	1.1	3.4	0.0	7.3	0.6
24	10.5	4.5	8.9	3.4	10.0	3.4	10.5	2.8	10.5	3.4	11.1	3.4	7.8	2.2	6.2	1.7
25	13.9	3.9	11.7	3.4	13.9	3.4	7.8	1.1	7.8	2.2	6.7	2.8	8.9	2.8	17.3	3.4
Maximum	15.0		12.2		16.7		13.3		16.7		14.5		8.9		17.3	
Minimum		-1.1		-2.8		-1.1		-1.7		-1.7		-1.7		-2.2		-1.7
Daily average	6.0		4.0		5.5		4.5		4.7		4.5		2.7		2.5	

Table IV. Mean daily wind values (km/hr), 1963.

Date (July)	Station* 1	2	3	4	5	6	7	U.S.W.B.	Direction
12	16.6	15.3	16.3	15.7	16.3	13.2	25.6	24.9	NNE
13	8.2	8.0	8.8	8.1	8.7	13.0	18.5	13.6	NNE
14	6.8	6.4	7.2	7.6	7.4	14.3	10.6	14.1	N
15	13.8	11.9	14.5	12.8	13.5	-	20.6	23.0	ENE
16	17.5	15.9	16.3	16.3	17.1	8.5	26.2	28.2	NE
17	7.7	7.4	8.5	7.7	8.4	10.6	12.1	14.0	WNW
18	11.4	10.3	12.4	10.6	11.6	8.4	17.4	18.8	W
19	9.0	8.0	9.7	8.4	9.2	10.5	13.3	14.3	WSW
20	10.3	8.7	10.3	8.8	9.8	6.9	14.3	16.1	E
21	19.0	17.1	19.0	16.4	17.4	11.5	27.0	29.6	E
22	11.7	10.4	11.2	10.4	10.9	10.1	17.2	18.7	NNE
23	11.2	10.1	10.6	9.5	10.3	9.7	15.6	15.4	NNE
24	8.4	7.4	8.2	7.2	8.4	9.7	12.4	12.5	SW
25	12.1	10.9	12.8	11.6	11.9	7.4	19.3	22.8	S
Mean	11.7	10.6	11.8	10.8	11.5	10.3	17.9	19.7	

*Numbers 1-6 located 65 cm above ground level.
Number 7 located approximately 7 m above ground level.

Table V. Comparison of precipitation (mm) between microclimatic stations and U. S. Weather Bureau, summer 1963.

Date measured	Average for all stations	U.S.W.B.
July		
16	2.5	3.2
17	0.5	1.3
24	0.5	0.5
25-26	1.8	1.3
27	2.3	2.0
28	11.7	10.6
August		
1	14.2	12.7
12	5.6	11.4
22	12.4	16.7
29	27.0	18.0
31	10.9	12.4
Total	89.4	90.1

Table VI. Classification and frequency of frost features.

Vegetation		Percentage bare soil exposed						
		B	C	D	E	F	G	
		80-100	40-80	20-40	10-20	1-10	<1	Total
onvex (C)	Vascular (V)	-	-	2	3	1	10	16
	Lichen-moss (L)	-	1	-	-	-	-	1
	Mixed (M)	1	-	1	1	-	8	11
	Total	1	1	3	4	1	18	28
aised (R)	Vascular (V)	43	19	4	11	12	36	125
	Lichen-moss (L)	7	9	4	8	19	22	69
	Mixed (M)	13	34	14	7	16	34	118
	Total	63	62	22	36	47	92	312
lat (F)	Vascular (V)	3	2	-	-	2	3	10
	Lichen-moss (L)	-	1	1	-	4	5	11
	Mixed (M)	1	2	1	-	4	3	11
	Total	4	5	2	0	10	11	32
	Total	68	68	27	30	58	131	372

rost feature area

An intricate part of the study area is the local occurrence of non-sorted circles and ın-sorted nets on the back slope of the beach ridge (see Fig. 2, 3, and 9). For purposes convenience the area is referred to as the frost feature area, denoting that the bare rcles and vegetated hummocks occur on the surface of the over-all pattern of ice-wedge ılygons. These frost features include circular, bare mineral and partially vegetated ars, and completely vegetated domes and hummocks. The orientation of the C-line ıs selected so that a representative segment of this frost active area would be included the sample plots. This location represents the most well-defined and concentrated ıllection of non-sorted circles in the Barrow area. It was originally mapped, described, d photographed by Drew (1957). Further investigation was deemed necessary, since understanding of this occurrence is paramount in analyzing frost susceptibility of ·ctic soils and related interactions of vegetation.

The first step in this study was the classification and further description and otographing of modal types. Table VI summarizes the classification system developed d the frequency of circular frost features. Figures 19 to 26 illustrate the more common ɔes. Selected soil and vegetation sampling is underway.

.crorelief studies

Microrelief is one of the physical parameters of the terrain that dominates soil aracteristics such as depth of thaw, chemical composition, moisture regimes, and ɜ distribution of vegetation types. The variation in topography within limited distances poses severe moisture and thermal gradients upon the soil and vegetation. It is de-ɾable to have a means of expressing the effect of microrelief upon soils and vegetation.

Microrelief studies on the plots include surveying for map preparation at a 5-cm ntour interval. Maps of the initial 20 plots have been prepared. The elevation is termined on a minimum of the 36 plot (Fig. 12) intersects for correlation with core d thaw analyses.

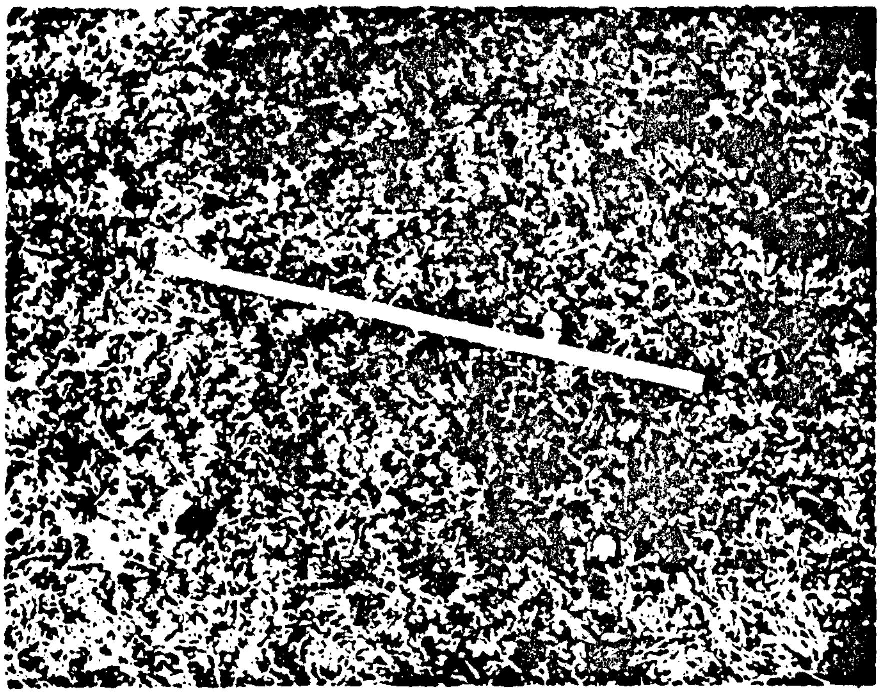


Figure 19. A single convex hummock raised 12 cm above the adjacent ground surface and completely vegetated with vascular and bryophyte species (CGM). The most abundant flowering plant is Eriophorum scheuchzeri.

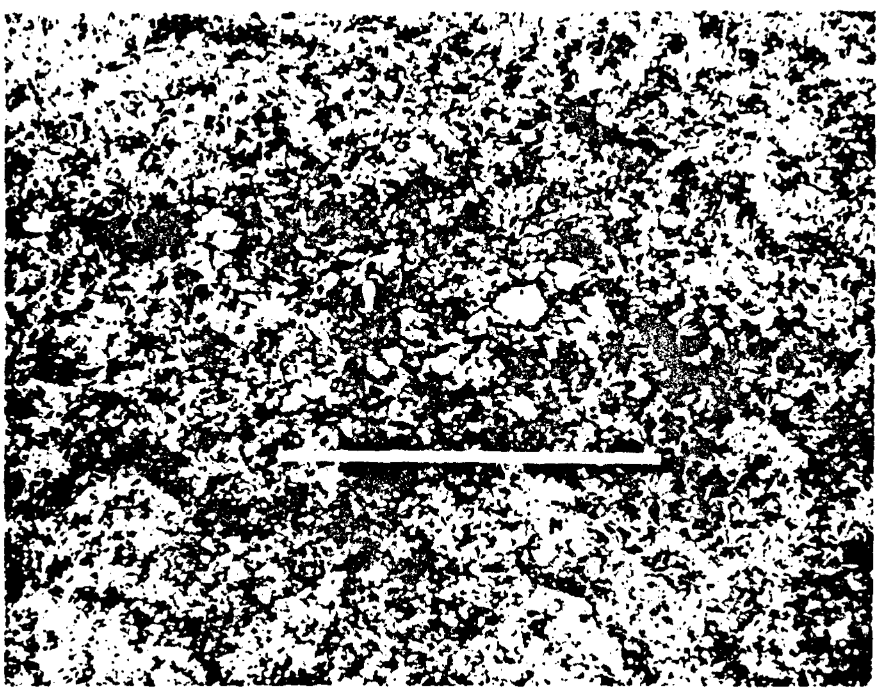


Figure 20. A flat area disturbed by frost heaving and distinguished from the adjacent tundra by the conspicuous bare mineral soil and lichen cover (FFL).

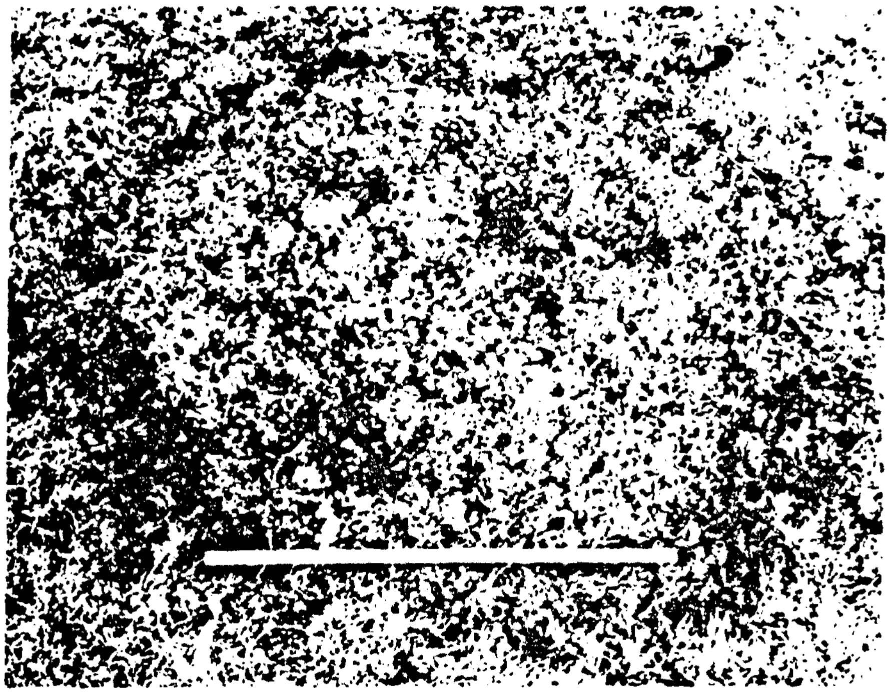


Figure 21. A raised feature completely vegetated with mosses, lichens, and vascular species (RGM).

Figure 22. A raised feature predominantly vegetated with lichens (REL). Note the conspicuous desiccation cracks.

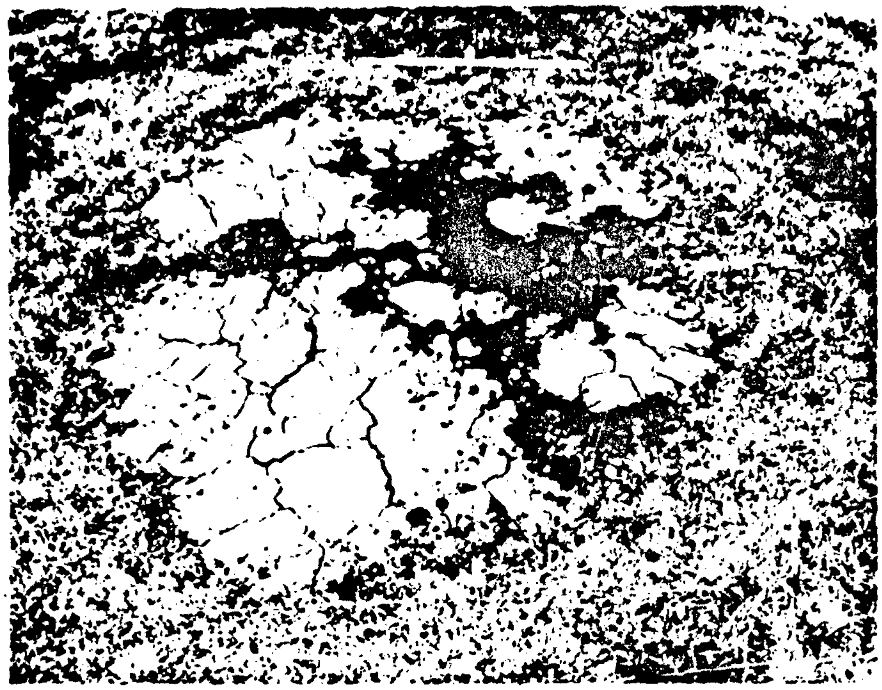


Figure 23. A pronounced turf ring surrounds a raised frost scar which is partially covered by mosses and lichens (RCL).

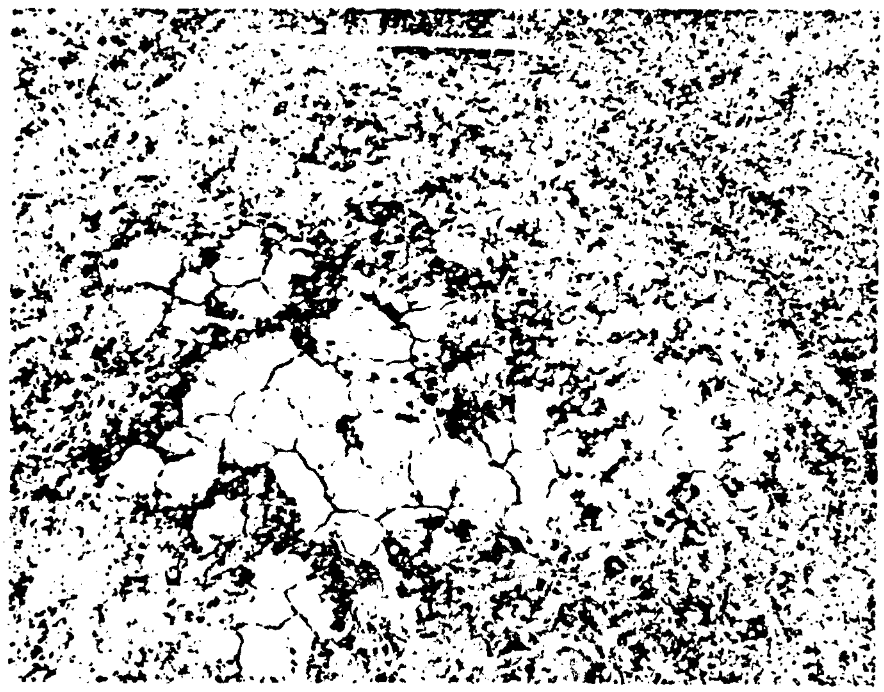


Figure 24. A raised frost scar with Petasites frigidus and a few lichens (RCM). The plants appear to be propagating along the desiccation network.

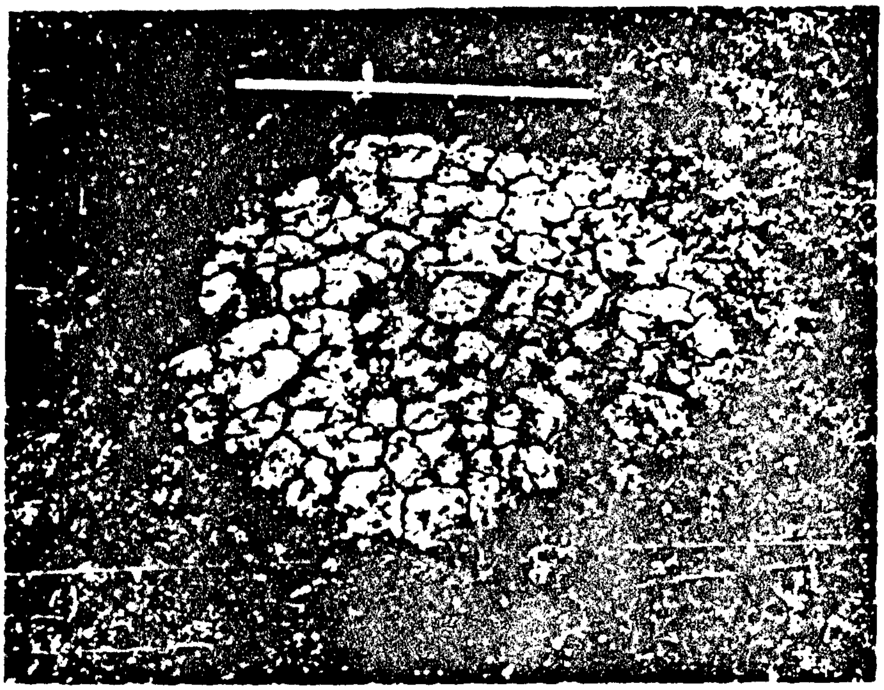


Figure 25. A narrow raised ring surrounds a frost scar which contains dead stems of vascular plants in the center (RBL).

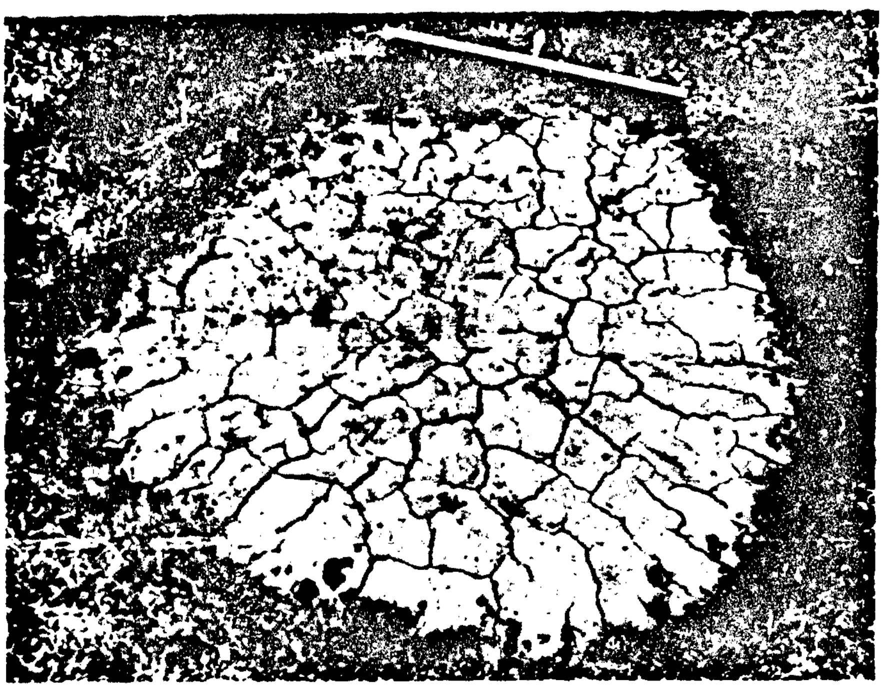


Figure 26. A weakly defined raised turf ring surrounds a bare frost scar (RBV). A few graminoid plants persist among numerous dead ones.

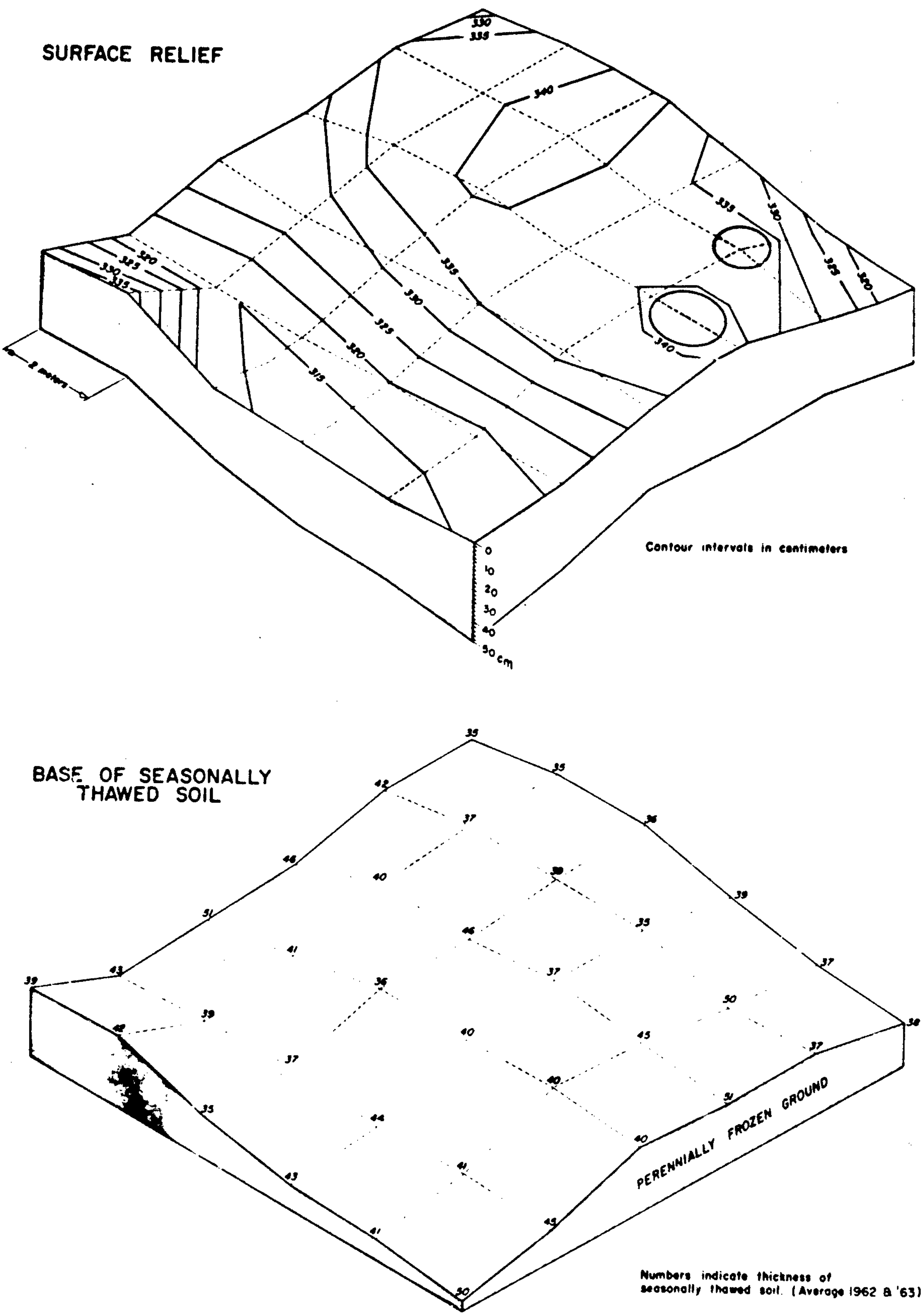


Figure 27. Surface microrelief and depth of thaw, Plot 37.

The effect of surface relief upon the depth of seasonal thaw in Plot 37 is observed in ;ure 27. The upper surface of the perennially frozen ground is more or less a replica the surface configuration. When the vegetation is removed or destroyed, as is the se with the bare mineral frost scars, the amount of thawed soil is increased. The esence of a dry peaty surface which is characteristic of the lichen-moss community nits the depth of seasonal thaw. The configuration of the lower boundary of the season-y thawed soil is undulating and irregular, not flat, a point which is paramount in the lerstanding of soil-water movement under saturated conditions.

Figures 28-31 illustrate typical types of microrelief encountered in the study area. attempt has yet been made to analyze the detailed topographic data in terms of sur-:e microgeometry or roughness. These data will be applicable to the computer pro-am used for analysis of vegetation and soil parameters.

Surveying of microelevations in the frost feature area has been extensive. Seasonal riations in the surface elevation of many non-sorted circles and nets were determined the thawed and frozen condition in order to evaluate changes in volume of the ground on freezing. A comparison of late summer (maximum thaw, 1962) and early summer itiation of thaw, 1963) elevations for the raised group of frost features yielded an :rease of approximately 2.5 cm between the unfrozen and frozen measurements. No end was evident based upon amount of vegetative cover.

In addition to studying the circles and nets, considerable attention was given to the er-all pattern of ice-wedge polygons in all stages of expressions from depressed-nter polygons to high-center polygons. The relation of elevations of polygon tops d troughs to the variability of soil, vegetation, and geomorphic expression is being termined.

CONCLUDING REMARKS

This report has briefly presented the objectives, design, and methodologies employed, d some preliminary results of a joint pedological and ecological investigation at rrow, Alaska. This cooperative approach to data collection and subsequent data duction promises to ultimately resolve pertinent environmental problems of this arctic osystem. These and related studies are not only providing the basis for understanding esent-day processes, but will also provide additional insight into past environments d ground conditions.

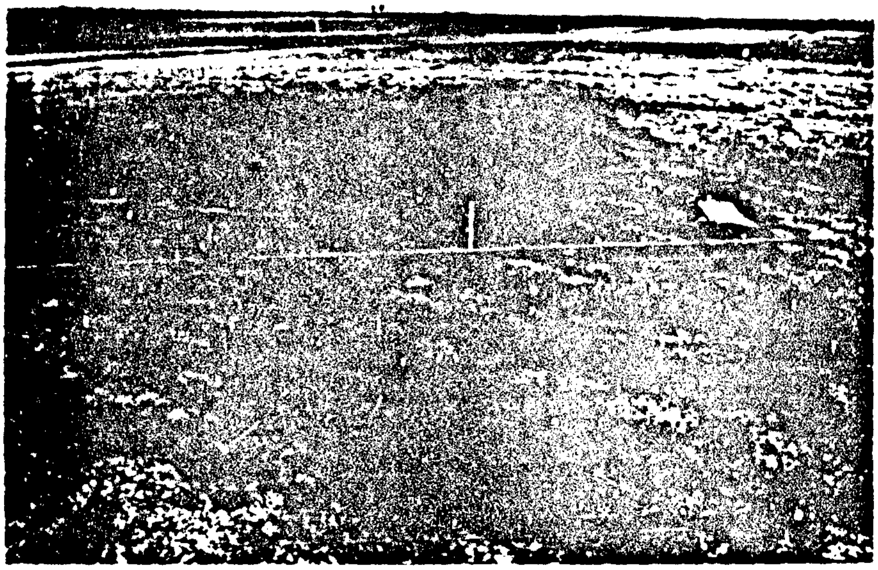


Figure 28. Ground photograph of Plot 48. The beach ridge is covered with hummocks which represents high-order repetitive microrelief. Petasites frigidus is the most conspicuous plant. Salix pulchra is confined to the southwestern exposures of these hummocks.

Figure 29. Ground photograph of Plot 37. Plot 37 characterizes the ice-wedge polygon microrelief and the frost features. Note frost scars and thermocouple installations.

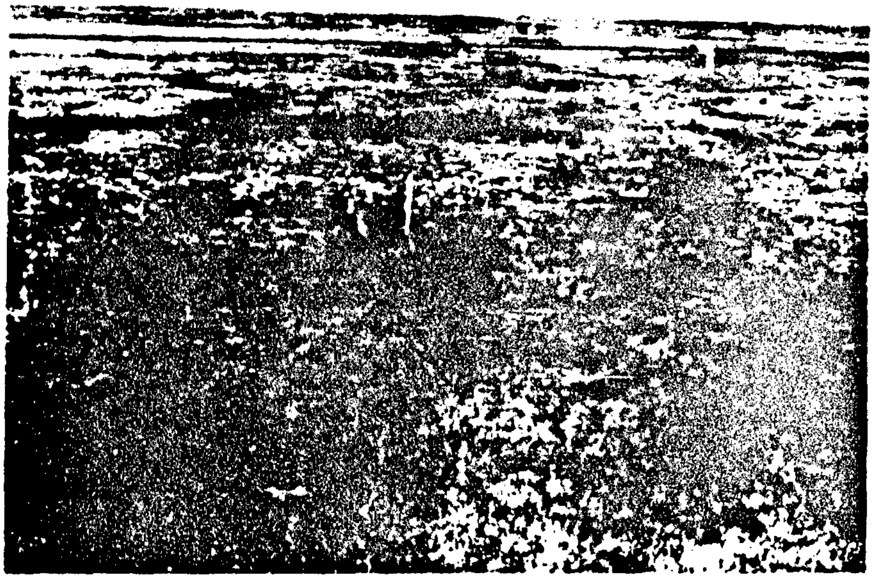


Figure 30. Ground photograph of Plot 29. This plot is dominated by Dupontia fisheri which is typical of wet tundra with minimal microrelief.

Figure 31. Ground photograph of Plot 16. This plot represents a gentle drainage slope with a relatively thick thaw zone.

REFERENCES

Bliss, L. C. (1962) Adaptations of arctic and alpine plants to environmental conditions, Arctic, vol. 15, p. 117-144.

Brewer, M. C. (1958) Some results of geothermal investigations of permafrost in northern Alaska, Transactions, American Geophysical Union, vol. 39, p. 19-26.

Britton, M. E. (1957) "Vegetation of the arctic tundra" in Arctic biology, 18th Annual Biological Colloquium, Oregon State College, p. 26-61.

Brown, J. (in prep.) Barrow, Alaska bibliography; a selected list of investigations on frozen ground and related subjects, U. S. Army Cold Regions Research and Engineering Laboratory (USA CRREL), Special Report.

Cantlon, J. E. (1961) Vegetation along environmental gradients in arctic Alaska, Ecological Society of America Bulletin, vol. 42, p. 127-191.

Churchill, E. D., and Hanson, H. C. (1958) The concept of climax in arctic and alpine vegetation, Botanical Review, vol. 24, p. 127-191.

Clebsch, E. E. C. (1957) The summer season climatic and vegetational gradient between Point Barrow and Meade River, Alaska, University of Tennessee, M.S. Thesis, 60p.

Drew, J. V. (1957) A pedologic study of Arctic Coastal Plain soils near Point Barrow, Alaska, Rutgers University, Ph.D. Thesis, 117p.

________, Tedrow, J. C. F., Shanks, R. E., and Koranda, J. (1958) Rate and depth of thaw in arctic soils, Transactions American Geophysical Union, vol. 39, p. 697-701.

Hultén, E. (1961) List of plants growing around the base at Barrow, Unpublished note, 27 July 1961, 2p.

Johnson, A. W. (1963) Plant ecology in permafrost areas, paper presented at International Conference on Permafrost, Purdue University.

Johnson, P. L. and Billings, W. D. (1962) The alpine vegetation of the Beartooth Plateau in relation to cryopedogenic processes and patterns, Ecological Monographs, vol. 32, p. 105-135.

Koranda, J. J. (1954) A phytosociological study of an uplifted marine beach ridge near Point Barrow, Alaska, Michigan State University, M. S. Thesis, p. 60.

Mather, J. R. and Thornthwaite, C. W. (1956) Microclimatic investigations at Point Barrow, Alaska, 1956, Drexel Institute of Technology, Laboratory of Climatology. Publications in Climatology, vol. 9, no. 1, p. 1-51.

________ (1958) Microclimatic investigations at Point Barrow, Alaska, 1957-1958, Drexel Institute of Technology, Laboratory of Climatology, Publications in Climatology, vol. 11, no. 2, p. 1-239.

Tedrow, J. C. F. and Cantlon, J. E. (1958) Concepts of soil formation and classification in arctic regions, Arctic, vol. 11, p. 166-179.

Wiggins, I. L. (1951) The distribution of vascular plants on polygonal ground near Point Barrow, Alaska, Contributions Dudley Herbarium, vol. 4, p. 41-52.

________ and Thomas, J. H. (1962) A flora of the Alaskan Arctic Slope, Arctic Institute of North America, Special Publication 4, p. 1-425.

Williams, W. T. and Lambert, J. M. (1959) Multivariate methods in plant ecology. I. Association-analysis in plant communities, Journal of Ecology, vol. 47, p. 83-101.

Vogel, T. C. and Johnson, P. L. (1964) An economical instrument shelter for microclimatological studies, USA CRREL Technical Note (unpublished), 10p.

APPENDIX A: PLANTS COLLECTED ALONG BARROW TRANSECT

Vascular Taxa

Poaceae

- Hierochloe pauciflora R. Br.
- Alopecurus alpinus J. E. Smith
- Arctogrostis latifolia (R. Br.) Griseb.
- Trisetum spicatum (L) Richt.
- Phippsia algida (Phipps) R. Br.
- Poa arctica R. Br.
- Arctophila fulva (Trin) Rupr.
- Dupontia fisheri R. Br.
- Festuca brachyphylla Schultes
- Calamagrostis neglecta (Ehrh) G. M. and Scher.

Cyperaceae

- Eriophorum angustifolium Honck.
- E. scheuchzeri Hoppe.
- Carex aquatilis Wahl.

Juncaceae

- Juncus biglumis L.
- Luzula confusa Lindb.
- L. nivalis (Laest) Beurl.

Salicaceae

- Salix phlebophylla Anders.
- S. pulchra Cham.
- S. rotundifolia Trautv.

Polygonaceae

- Rumex arcticus Trauv.
- Oxyria digyna (L) Hill
- Polygonum viviparum L.

Caryophyllaceae

- Stellaria humifusa Rottb
- S. laeta Richards
- Cerastium beeringianum Cham. and Schlecht

Ranunculaceae

- Caltha palustris var arctica (R. Br.) Huth.
- Ranunculus nivalis L.
- R. pallasii Schlecht

R. pygmaeus Wahl.

R. sabinei R. Br.

Papaver radicatum Rottb.

Cruciferae

Cochlearia officinalis subsp. arctica (Schlecht) Hultén

Cardamine pratensis Cham. and Schlecht

Draba sp.

Saxifragaceae

Saxifraga caespitosa subsp. uniflora (R. Br.) A. E. Porsild

S. cernua L.

S. flagellaris Willd.

S. foliolosa R. Br.

S. hieracifolia Waldst. and Kit.

S. hirculus L.

S. nivalis L.

S. oppositifolia L.

S. rivularis L.

Chrysoplenium tetrandrum (Lund) Th. Fries

Rosaceae

Potentilla hyparctica Malte

Dryas integrifolia Vahl.

Ericaceae

Cassiope tetragona

Vaccinium vitis-idaea subsp. minus (Lodd.) Hultén

Haloragidaceae

Hippuris vulgaris L.

Scrophulariaceae

Pedicularis sudetica Willd.

Pedicularis lanata Cham. and Schlecht.

Compositae

Petasites frigidus L.

Senecio atropurpureus (Ledeb) Fedtsch.

MOSSES

Aulacomnium turgidum (Wahl.) Schwaegr.

Calliergon sarmentosum (Wahl.) Kindb.

Ceratodon purpureus (Hedw.) Brid.

Distichium capillaceum Hedw.

Dicranum elongatum Schleich.

Ditrichum flexicaule (Schwaegr.) Hampe

Haplodon wormskijoldii (Hornem.) R. Brown

Pogonatum alpinum (Hedw.) Roehl.

P. juniperinum Hedw.

Psilopilum cavifollium (Wils.) Hag.

Sphagnum fuscum Klingg.

S. squarrosum Pers.

S. subsecundrum Nees

Splachnum vasculosum (L.) Hedw.

Tetraplodon minoides Hedw.

LIVERWORTS

Blepharostoma trichophylla Linn

Lophozia sp.

Sphenolobus minutus

LICHENS

Cetraria cucullata (Bell.) Ach.

C. crispa (Ach.) Nyl.

C. islandica (L.) Ach.

C. nivalis (L.) Ach.

C. richardsonii Hook.

Cladonia bellidifolia (Ach.) Schaer.

C. chlorophaea (Flk) Spreng.

C. pleurota (Flk) Schaer.

Cornicularia divergens Ach.

Dactylina arctica (Hook.) Nyl.

Nephroma expallidum Nyl.

Pannaria sp (pezizoides (Web.) Trev.)

Sphaerophorus globosus (Huds.) Vain.

Stereocaulon paschale (L.) Hoffm.

Thamnolia subuliformis (Ehrh.) Culb.

T. vermicularis (Sw.) Ach.

APPENDIX B: ASSOCIATED INVESTIGATIONS

ı addition to the programs reviewed in this report, a number of other investigations ·esently being conducted at Barrow by the authors and project personnel. A ıent of purpose and status are presented here.

surface lithology

o determine lithologic units in the near-surface sediments of the Barrow ırea and late surface features and soils with subsurface materials including ground ice. termine the sedimentary, late- and post- Pleistocene history of the area.

apers. Near-surface lithology of the Barrow, Alaska area - a preliminary report, Sellmann and J. Brown, 1963, Fourteenth Alaskan Science Conference, Proceed- p. 231-232, abstract.

ear-surface stratigraphy, Barrow, Alaska-core analysis, P. V. Sellmann, ɔwn and R. I. Lewellen, 1964, presented at Fifteenth Alaskan Science Conference.

adiocarbon dating, Barrow, Alaska, J. Brown, submitted to Arctic, Sept 1964.

edge chemistry

o determine the chemical composition of massive ground ice and evaluate its ɔle significance for ice-wedge growth and for soil and surface water changes in st. To tunnel through a buried ice mass and examine its contacts with encasing ent and surface wedges, and to further develop techniques of age determination ;h radiocarbon dating.

'aper. Ice-wedge chemistry and related frozen ground processes, J. Brown, 1963, presented at International Conference on Permafrost, Purdue University.

·w bibliography

o prepare and maintain a bibliography for the Barrow, Alaska area that is per- to frozen ground investigations.

pecial CRREL report. Barrow, Alaska bibliography, a select list of investiga- on frozen ground and related subjects - J. Brown (in preparation).

·shed studies

'o measure the chemical balance in an Arctic Coastal Plain watershed in order to ıte the magnitude of chemical depletion in wet tundra soils.

ıterim report. Chemical balance for an arctic watershed, J. Brown, R. I. .len, and P. V. Sellmann, April, 1964.

nal erosion studies

o evaluate changes in surface morphology based upon thermal erosion of water ıanges in climate utilizing ground measurements and sequential photography.

graphic interpretation

'o utilize sequential ground and aerial photography to determine the distribution ɜlative changes in disturbed and undisturbed vegetation and surface features. : studies are based on remote sensing of the arctic terrain and include use of romatic, color, infrared, and radar imagery.

'apers. An economical instrument shelter for microclimatological studies, Vogel and P. L. Johnson, 1964, USA CRREL Technical Note, 10p.

'he application of multiband aerial sensing to problems in plant ecology, P. L. on, 1964, International Botanical Congress, Edinburgh.

;raphic mapping

'o prepare topographic maps of $\frac{1}{2}$-m contour interval in the immediate Barrow in order to provide data required for the interpretation of micro- and macrorelief studies, near-surface lithology, and relateu investigations. Mapping photography and field control were obtained in summer 1964 and map compilation is scheduled for completion by June 1965 for the area north of 71° 15'.

Physiological ecology

To determine in situ the rates of photosynthesis, respiration, and transpiration of selected species and to relate these processes to environmental interactions.